APPENDIX C
Example of Typical Cost Analysis

This appendix provides a method for evaluating the economic advantages of using one material and/or method in lieu of others. The approach presented here may be used, with little modification, to evaluate the relative economic advantages of any selection of building or structure maintenance alternatives.

This example analysis is a life cycle cost study of painting existing wood siding versus overlaying existing siding with new prefabricated siding and insulation. It is divided into four parts. Paragraph C.1 discusses general factors impacting on the study. Paragraph C.2 compares continuing the present system, but with insulation added to the outside and protected by new siding-any kind of siding. Paragraph C.3 compares four types of factory prefinished siding with sufficient insulation added to provide each type with the same degree of thermal energy conservation. Paragraph C.4 provides the cost data source for all the figures used in C.2 and C.3 and a generic description of the four fictional materials used as siding overlayment.

C.l General

C.1.1 Purpose

To provide an evaluation of the economic advantages of installing new exterior prefabricated siding and insulation over wood siding in lieu of repainting the existing wood siding.

C.l.2 Consideration of Useful Life

Only those maintenance alternatives which have a useful life shorter than, or equal to, the remaining useful life of the structure should be evaluated. Generally, major repairs should be accomplished on only those facilities identified on the approved installation master plan as being approved for long-term retention and utilization.

C.1.3 Estimating Useful Life

The estimate of remaining useful life should be based on sound engineering judgment considering the total facility, including all necessary structural, mechanical, and functional elements necessary to realize the remaining useful life.

C.1.4 Life Cycle Costing

Life cycle costing is the evaluation of the total of all costs and savings identified with a particular alternative throughout the useful life of that alternative. Life cycle costs can be compared by equating all costs to their present value cost. When comparing life cycle costs, care must be taken that the life cycle considered is for the same length of time for each alternative and does not exceed the expected retention time for that facility.

C.1.5 Present Value Cost

Present value cost is the sum of money that will grow at a prescribed interest rate to either a specified sum in one particular year or will grow to annual equal expenditures over a specified number of years. It is the amount of money, if put into an interest-bearing account, will be just sufficient to cover each cost as the cost arises. The account's rate of interest would be the current discount rate adjusted by the projected rate of inflation. The discount rate is prescribed by the appropriate regulation for each service, and is used at 10 percent in the examples that follow below.

C.l.6 Selection of Alternative

The alternative with the lowest present value cost, including any initial cost, is the most economical. A final selection based upon features not expressible in monetary terms and not shown to be most economical must be justified.

C.1.7 Estimating Costs

Cost estimates for life cycle costing should be made using known comparable costs whenever possible. These may be obtained from local facility records, records at other facilities, higher commands, and current commercially published and nationally recognized estimating manuals. The source of all cost estimates should be documented and cost estimate computations should be included with the cost analysis.

C.1.8 Recurring Costs

All costs recurring annually or at intervals must be escalated to the time expenditure is made. Energy Conservation Investment Program procedures and other regulations provide guidance for escalation rates of usual construction, maintenance and repair costs, and energy types. Energy escalation costs vary depending on the energy source (see table C-1).

TABLE C-1. — Escalation Rates

Type	Rate (pct)
Coal	5.0
Fuel Oil	8.0
Natural or Liquid Petroleum Gas	8.0
Electricity	7.0

The escalation rate and discount rate are combined into cost factors in table C-2. Costs recurring at intervals must use the "one-time cost factors" in the first column of each table.

The accumulative total cost shown in the second column may be used when the basic cost item occurs each year. In the absence of better information, escalation rates for replacement, repair, and maintenance costs may be taken at 5 percent. If any future costs are forecast by more accurate means, such as an appropriate regulation, the present value is obtained by using the estimated future cost and the 0 percent rate as shown in table C-2 Rate A. In all four tables in table C-2, the discount rate is 10 percent.

Table C-2 — Differential Escalation Discount Factors

The one-time cost factors are likely to be applied to one-time costs occurring in isolated years after the program year. Recurring *benefits/cost* factors are to be applied to identical annually recurrent cash flow. * These factors are to be applied to cost elements which are anticipated to escalate at the same rate *as* the general price level.

Economic life years	Rate A		Rate B	
	Differential inflation rate—0%* Discount rate—10%		Differential inflation rate—5%* Discount rate—10%	
	One-timecost factors	Recurring benefits/cost factors	One-time cost factors	Recurring benefits/cost factors
1	0.954	0.954	0.977	0.977
2	0.867	1.821	0.933	1.910
3	0.788	2.609	0.890	2.800
4	0.717	3.326	0.850	3.650
5	0.652	3.977	0.811	4.461
6	0.592	4.570	0.774	4.461
7	0.538	5.108	0.739	5.974
8	0.489	5.597	0.706	6.680
9	0.445	6.042	0.673	7.353
10	0.405	6.447	0.643	7.996
11	0.368	6.815	0.614	8.610
12	0.334	7.149	0.586	9.196
13	0.304	7.453	0.559	9.755
14	0.276	7.729	0.534	10.288
15	0.251	7.980	0.509	10.798
16	0.226	8.209	0.485	11.284
17	0.208	8.416	0.464	11.748
18	0.189	8.605	0.443	12.191
19	0.172	8.777	0.423	12.614
20	0.156	8.993	0.404	13.018
21	0.142	9.074	0.385	13.403
22	0.129	9.203	0.368	13.771
23	0.117	9.320	0.351	14.122
24	0.107	9.427	0.335	14.458
25	0.097	9.524	0.320	14.777

Economic life years	Rate C		Rate D	
	Differential inflation rate—7%* Discount rate—10%		Differential inflation rate—8%* Discount rate—10%	
	One-timecost factors	Recurring benefits/cost factors	One-time cost factors	Recurring benefits/cost factors
1	0.986	0.986	0.991	0.991
2	0.959	1.946	0.973	1.964
3	0.933	2.879	0.955	2.919
4	0.908	3.787	0.938	3.857
5	0.883	4.670	0.921	4.777
6	0.859	5.529	0.904	5.681
7	0.836	6.364	0.888	6.569
8	0.813	7.177	0.871	7.440
9	0.791	7.968	0.856	8.296
10	0.769	8.737	0.840	9.136
11	0.748	9.485	0.825	9.961
12	0.728	10.212	0.810	10.770
13	0.708	10.920	0.795	11.565
14	0.688	11.608	0.781	12.346
15	0.670	12.278	0.766	13.112
16	0.651	12.930	0.752	13.864
17	0.634	13.563	0.739	14.603
18	0.616	14.180	0.725	15.329
19	0.600	14.779	0.719	16.041
20	0.583	15.363	0.699	16.740
21	0.567	15.930	0.687	17.427
22	0.552	16.482	0.674	18.101
23	0.537	17.019	0.662	18.762
24	0.522	17.541	0.650	19.412
25	0.508	18.049	0.638	20.050

C.l.9 Applicability

The policy and method outlined herein are applicable to all buildings with siding problems, including family housing.

C.1.10 Designation of Siding as Repair

If the existing siding has deteriorated or will not successfully hold paint for the minimum period presented in the appropriate regulations, re-siding may be classified as repair when life cycle costing proves re-siding to be the most economical alternative.

C.2 Insulation Comparison

C.2.l Options Considered

Two options were considered: Option I — Sandblasting and repainting; or Option II — Overlayment residing. Various types of siding coupled with various types and thicknesses of insulation should be considered to arrive at an optimum combination. Factors to be considered are:

C.2.1.1 *Initial Construction Costs*. Re-siding costs should include the finish and trim material around doors, windows, vents, utility service, and mechanical equipment. These trim costs will vary with the various thicknesses of insulation selected and the greater thicknesses may require extensive reworking of jambs, sills, and heads.

C.2.1.2 *Annual Maintenance Costs*. In spite of manufacturers' claims, siding is not maintenance free. An estimate must be made of the amount that has to be replaced each year due to abuse and accidental damage.

C.2.1.3 *Energy Savings*. Increases in thickness of insulation will produce increases in fuel savings with diminishing savings until an optimum is reached. Some sidings provide R values as an inherent characteristic while others such as unbacked aluminum, steel, and vinyl provide negligible values. The U factor of the complete system must be considered in the analysis.

C.2.1.4 *Appearance Life Expectancy of Siding*. After a number of years all brands of siding exhibit some color shift. Eventually there will be a dam-aged panel replaced with new material which will differ significantly in color from the existing. When the color differences become unsightly, it will be necessary to paint the entire wall even though the original finish is sound.

C.2.1.5 *Life Expectancy of Substrate*. All substrates will eventually wear out. Excessive moisture, corrosive atmosphere and sunshine will cause siding to rust, corrode or shatter requiring complete replacement.

C.2.2 Life Cycle Energy Cost Comparison

Increased insulation reduces annual energy costs and increases initial installation and annual maintenance costs. Greater amounts of insulation may produce unusual installation problems and increase the initial costs disproportionately to the energy saving. The optimum amount of insulation can only be determined by complete analysis of costs and savings. According to table 9-2, DoD Construction Criteria Manual 4270.1M, buildings to be heated to 65° F (18.4° C) must have a U-factor in walls of 0.1 Btu/hr-ft^2-F either in new construction or in repair renovation work. While a U-factor of 0.1 may not represent the optimum value it is the maximum requirement and will serve as a basis for comparing energy costs with the existing wall.

C.2.2.1 *Example assumptions:*

Exterior Building wall Area	=	4000 ft 2
Fuel Oil Cost Escalation Factor	=	8 et
Electricity Cost Escalation Factor	=	7 et
Construction Cost Escalation Factor	=	5 pet
Differential Inflation Discount Rate	=	10 pet
Retention Time of Building	=	5 yrs
Design Heating Temperature Difference	=	48°F (8.9°C)
Equivalent Cooling Temperature Difference . . .	=	35°F (1.7°C)

C.2.2.2 *Comparison Analysis:*

Item	*Unit cost*	*Cost source **	*PV factor*	*Cost*
OPTION I — Continue Existing System				
Repaint	1365	C.14.4.1	1.0	$1,365
Repaint	455	C.14.4.1	4.461	2,030
Heat	1606	C.14.4.1	4.777	7,672
Cool	288	C.14.4.1	4.670	1,345
Total Cost				$12,412
OPTION II — Insulated to U=0.1 with siding overlayment				
Reside	5925	C.14.4.3	1.0	$5,925
Repair	38	C.14.4.3	4.461	167
Heat	703	C.14.4.2	4.777	3,358
Cool	126	C.14.4.2	4.670	588
Total Cost				$10,038

*Paragraph number of cost data source.

C.2.2.3 *Conclusions*. Adding insulation to a relatively uninsulated building is cost effective and be-comes even more cost effective as fuel prices rise. The optimum thickness of insulation may be determined by using realistic costs and retention time of building. It appears that adding insulation with new siding overlayment would not be cost effective for retention times of less than 5 years. For the balance of this illustrative example it is assumed the optimum U-factor is 0.10 Btu/hr-ft^2-F.

C.3 Siding Comparison

C.3.1 Life Cycle Siding Costs

Having determined that adding insulation will be cost effective for the building retention time, comparisons with continuing existing siding may be eliminated. The justification for one type of siding over others will depend on current installed costs of siding; effective life expectancy of the siding substrate before complete replacement is required; effective life expectancy of the siding finish material before cyclical repainting in required; and retention time of building. In the example that follows four types of siding are selected, all obtaining the same U factor by adding appropriate amounts of insulation. Building retention time is not determined in order to illustrate the impact retention time has on final decision.

C.3.2 Example assumptions

Building will be the same as in C.2 except building retention time is unspecified and siding characteristics are as follows:

C.3.2.1 *Siding Material* "A"—A heavy duty siding with a factory-bonded high-qualify film finish material. The siding requires ¾ inch of rigid polystyrene insulation board to obtain the required U-factor. The finish material is estimated to require 4-year cyclical painting starting in the 21st year, with complete replacement of the substrate in the 31st year.

C.3.2.2 *Siding Material* "B"—A light-duty siding with a factory-applied paint finish. The siding requires ¾ inch of rigid polystyrene insulation board to obtain the required U4actor. The finish material is estimated to require 4-year cyclical painting staring in the 13th year, with complete replacement of the substrate in the 25th year.

C.3.2.3 Siding Material "C"—A heavy-duty siding with a factory applied enamel paint finish. The siding requires ¾ inch of rigid polystyrene insulation board to obtain the required U-Factor. The finish material is estimated to require 4-year cyclical painting, starting in the 13th year with compete replacement of the substrate in the 31st year.

C.3.2.4 *Siding Material* "D"— wood fiberboard having a factory-appied paint finish. The siding has inherent insulative value requiring ¼ inch of additional rigid polystyrene board insulation to achieve the required U/factor. The finish material is estimated to require 3-year cyclical painting, starting in the 9th year, with complete replacement of substrate in the 15th year.

C.3.3 Comparison Analysis

Since U-factors are equal for all cases, the fuel costs will be equal and may be eliminated from the analysis. Present value costs, in the year occurring, are tabulated in table C-3.

TABLE C-3. -Present Value Costs of Sidings

Year	Siding material "A" P.V. of M&R costs*	"A" Accum. total costs	"B" P.V. of M&R costs*	"B" Accum. total costs	"C" P.V. of M&R costs*	"C" Accum. total costs	"D" P.V. of M&R costs*	"D" Accum. total costs	Yr
0	6725	6725	5925	5925	6125	6125	4825	4825	0
5	126	6851	122	6047	324	6449	20	5028	5
9	104	6955	101	6148	269	6718	594	5622	9
12	—	6955	—	6148	—	6718	752	6374	12
13	87	7042	442	6590	581	7299	—	6374	13
15	—	7042	—	6590	—	7299	2456	8830	15
17	72	7114	552	7142	668	7967	—	8830	17
20	—	7114	—	7142	—	7967	101	8931	20
21	306	7420	458	7600	554	8521	—	8931	21
24	—	7420	—	7600	—	8521	296	9297	24
25	382	7802	1896	9496	461	8982	—	9227	25

*Present Value of Maintenance and Repair costs is obtained by multiplying current cost data presented in paragraph C.14.4 by the Recurring Benefits/Costs factors for the year the cost will be incurred as shown in table C-2.

C.3.4. Conclusion

The foregoing tabulation of costs indicates that for retention periods of less than 11 years, siding overlayment material "D" should be used. For 12 to 16 years-siding overlayment material"B" should be used, and for periods of 17 years or greater, siding overlayment material "A" should be selected.

C.4 Cost Data

C.4.l Wall U-values Option I-Existing:

Wall component	R-value Through Wall	R-value Through Framing
Outside Air Film (15-mph wind)	0.17	0.17
3/4-inch shiplap siding	1.05	1.05
3/4-inch solid wood sheathing	0.94	0.94
3-1/2-inch airspace	1.01	—
Nominal 2" x 4" wood stud	—	4.38
1/2-inch gyppsum wall board	0.45	0.45
Inside air film	0.68	0.68
R =	4.30	7.67
TOTAL U = 1/R	0.233	0.13

Using:

$$U_{av} = \frac{S}{100}(U_s) + \left(1 - \frac{S}{100}\right)(U_i) \quad \text{EQ. 9}$$

(1977 ASHRAE Fundamentals Handbook, pg. 22.5)

Where:

U_{av} = Average U-value for building section
U_i = U-value for area between framing members
U_s = U-value for area backed by framing members
S = Percentage of area backed by framing members

Assume 20 percent framing.

$$U_{av} = \frac{20}{100}(0.13) + \left(1 - \frac{20}{100}\right)(0.233)$$

$$= 0.21 \text{ Btu/hr-ft}^2\text{-F}$$

Option II—Overlayment re-siding with insulation:

Wall component	R-value	
	Through Wall	Through Framing
Existing	4.30	7.67
New siding with d inch insulating board/foil-backed	1.82	1.82
3/4-inch rigid polysterene	4.16	4.16
R =	10.28	13.65
TOTAL U = 1/R	0.097	0.073

$$U_{av} = \frac{S}{100}(U_s) + \left(1 - \frac{S}{100}\right)(U_i) =$$

$$U_{av} = \frac{20}{100}(0.073) + \left(1 - \frac{20}{100}\right)(0.097) =$$
$$= 0.092 \text{ Btu/hr-ft}^2\text{-F}$$

The differences in R-value between the most common types of siding — steel, aluminum, and solid vinyl are negligible. However, some sidings are themselves significantly insulative or are manufactured with an integral insulation backer layer and the U-values of these types should be calculated independently. Various thicknesses of insulation impact on fuel savings. A separate preliminary analysis should be made of differing thicknesses of insulation to determine the thickness and corresponding U-value for optimum savings over the life of the building. Included should be the variable costs of finishing around doors, windows, etc., and special means of support and attachment for the greater thicknesses of insulation. In this example the optimum thickness of insulation is assumed to be 3/4 inch of rigid polystyrene which produces a U-value lower than the maximum of 0.10 required by DOD regulations in new or rehabilitative work.

C.4.2 Heating and Cooling Loads

C.4.2. 1 Use the equation $Q = U_{av}A(t_i - t_o)$ to determine the heat gain and loss in Btu per hour. U_{av} is the coefficent determined in C.4.1. above, A is the wall area, and$(t_i - t_o)$ is the difference between the design interior and design exterior temperature in ° Fahrenheit.

Heating:

Existing Q = (0.21)(4,000)(65-17) = 40,820 Btu/hr
With Overlayment Q = (0.092)(4,000)(65-17) = 17,664 Btu/hr

C.4.2.2 Use the equation $Q = U_{av}A(CLTD)$. Assume frame wall, each exposure having equal area, i.e., 1,000 ft^2 on north, east, south, and west walls. The average Cooling Load Temperature Difference (CLTD) = 35°F @ 1,400 hr, ASHRAE Fundamentals Handbook, Table 7,1977, p.25.9. (Calculations are made on transmitted sensible heat gain only. Other heat gains are not affected by siding modifications.)

Cooling:
Existing Q = (0.21)(4,000)(35) = 29,400 Btu/hr
With Overlayment Q = (0.092)(4,000)(35) = 12,880 Btu/hr

C.4.3 Energy Consumption Estimates

Heating: Using eq. 1 on p. 43.8 of the 1976 ASHRAE Systems Handbook for calculating energy consumption by the Modified Degree Day Method:

$$E = \left(\frac{H_L \times D \times 24}{t \times V}\right) C_D\ C_F$$

E = Fuel consumption for the estimate period
HL = Design heat loss, Btu/hr
D = Degree days; assume 3865 F —Day
t = Temperature difference = (65 — 17)
= Rated efficiency; assume 70 pct
V = Heating value of fuel; 138,700 Btu/gal for distillate fuel oil
C_D = Correction factor for heating effect vs degree days
C_F = Part load correction factor
Table 3*, assume 40 percent oversizing, CF = 1.79
Table 2*, 17°F design temperature C_D approx. = 0.86
*1976 ASHRAE Systems Handbook, p.43.8

C.4.3.1 *Existing Siding*, H_L = 40,320 Btu/hr

$$E = \left(\frac{40{,}320 \text{ Btu/hr} \times 3865 \text{ F} - \text{Day} \times 24 \text{ hr/day}}{48 \text{ F} \times 0.70 \times 138{,}700 \text{ Btu/gal}} \right)$$

$$(0.86)(1.79)$$

E = 1,235 gal
Cost = 1,235 gal x $1.30/gal
Cost $1,606/year

C.4.3.2 *Siding Overlayment*, $H_L = 17{,}664$ Btu/hr

$$E = \left(\frac{17{,}664 \times 3865 \times 24}{48 \text{ F} \times 0.70 \times 138{,}700} \right)(0.86)(1.79)$$

E = 541 gal
Cost = 541 gal x $1.30/gal
Cost $703

C.4.3.3 *Cooling:* Use Equivalent Full Load Hour Method. Assume 1200 full load hours of operation of equipment. Using Table 4 on p.43.9 in the 1976 ASHRAE Systems Handbook, and assuming central air conditioning unit; power input is approximately 1.63 kW/ton.

a. Existing Siding:

$$E = \frac{29{,}400 \text{ Btu/hr} \times 1.63 \text{ kW/ton} \times 1{,}200 \text{ hr}}{12{,}000 \text{ Btu/hr/ton}}$$

$$= 4{,}792 \text{ kWh}$$

Cost = 4,792 kWh x $0.06/kWh = $288/yr

b. Siding Overlayment:

$$E = \frac{12{,}880 \text{ Btu/hr} \times 1.63 \text{ kW/ton} \times 1{,}200 \text{ hr}}{12{,}000 \text{ Btu/hr/tonl}}$$

$$= 2{,}099 \text{ kWh}$$

Cost = 2,099 kWh x $0.06/kWh = $126/yr

C.4.4 Construction Costs:

a. *Existing Siding*

Paint wood siding (primer + 1 coat)0.26/ SF × 4,000 SF	=	$1,040
Paint wood trim (primer + 1 coat)0.44/ SF × 200 SF	=	88
Windows and doors (primer + 1 coat)0.25/ SF × 500 SF	=	125
Repair of Siding 2.80/SF x 40 SF	=	112
Total — Initial and M&R costs each 3 years		$1,365
Average annual cost ÷ $1,365-3	=	455

b. Sliding Overlayment—Material "A "—Life expectancy of substrate is 30 years and finish is 20 years. Repainting will start in 21st year with complete replacement of siding in 31st year.

Install new siding overlayment 1.15/ SF × 4,000 SF	=	$4,600
Bead-board backer 0.10/SF × 4,000 SF	=	400
3/4" polystyrene foam insulation 0.40/ SF × 4,000 SF	=	1,600
Paint windows and doors (as above) 0.25 SF × 500 SF	=	125
Total — Initial Cost and Replacement Cost in 31st Year		$6,725
Replace damaged siding 3.00/SF × 10 SF	=	$30
Paint windows and doors (as above) 0.25/ SF × 500SF	=	125
Total — M&R Costs (5th yr and each 4 yrs thereafter)	=	$155
Paint without priming (1 coat) 0.16/ SF × 4,0005F	=	640
Total — M&R Cost in 21st year		$795
Repaint Siding: Add prime coat 0.10/ SF × 4,000SF	=	400
Total — M&R Cost after 21st year	=	$1,195

c. Siding Overlayment—Material "B"—Life expectancy of substrate is 24 years and finish is 12 years. Repainting will start in 13th year with complete replacement of siding in 25th year.

Install new siding overlayment 0.95/ SF × 4,000 SF	=	$3,800
Bead-board backer (as above)	=	400
3/4-inch polystyrene foam insulation (as above	=	1,600
Paint windows and doors (as above)	=	125
Total — Initial Cost and Replacement Cost in 25st Year		$5,925
Replace damaged siding 2.50/SF × 10 SF	=	$25
Paint windows and doors (as above)	=	125
Total — M&R Costs (5th yr and each 4 yrs thereafter)	=	$150
Average annual M&R cost 150:×4	=	38
Paint without priming (as abive	=	640
Total — M&R Cost in 13th year		$790
Repaint Siding: Add prime coat (as above)	=	400
Total — M&R Cost after 13th year	=	$1,190

d. Siding Overlayment-Material "C"—Life expectancy of substrate is 30 years and finish is 12 years. Repainting will start in 13th year with complete replacement in 31st year. Although the life expectancy of this siding substrate is quite long it is highly susceptible to damage therefore annual maintenance costs are high.

Install new siding overlayment $1.00/ Sfx4,000 SF	=	$4,000
Bead-board backer (as above)	=	400
3/4-inch polystyrene foam insulation (as above)	=	1,600
Paint windows and doors (as above)	=	125
Total—Initial Cost and Replace ment Cost in 3lth year	=	$6,125
Replace damaged siding 2.75/SFx 100 SF	=	$275
Paint windows and doors (as above)	=	125
Total—M&R Costs (5th yr and each 4 yrs thereafter)	=	$400
Paint without priming (as above)	=	640
Total—M&R Cost in 13th year	=	$1,040
Repaint Siding: Add prime coat (as above)	=	400
Total—M&R Cost after 13th year	=	$1,440

e. Siding Overlayment-Material "D"—Life expectancy of substrate is 14 years and finish is 8 years. Repainting will start in 9th year with complete replacement of siding in 15th year.

Install new siding overlayment 0.95/ SF × 4,000 SF	=	$3,800
d inch rigid polystyrene insulation 0.25/ SF × 4,000 SF	=	1,000
Paint windows and doors (as above)	=	125
Total--Initial Cost and Replacement Cost in 15th year	=	$4,825
Replace damaged siding 2.50/SF × 50 SF	=	$125
Paint windows and doors (as above)	=	125
Total—M&R Costs (5th yr and 20th yr)	=	$250
Paint without priming (as above)	=	640
Total—M&R Cost in 9th and 24th yr	=	$890
Repaint Siding: Add prime coat (as above)	=	400
Total—M&R Cost in 12th year	=	$1,290